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Toxoplasma gondii levels in swine operations: differences due to technology choice and impact on costs of production

Chun-Hsuan Wang [a], Vina Diderrich [b], James Kliebenstein [a,*], Sharon Patton [b], Jeff Zimmerman [a], Arne Hallam [a], Eric Bush [c], Charles Faulkner [b], Raymond McCord [b]

[a] *Department of Economics, Iowa State University, 178 Heady Hall, Ames, IA 50011-1070, USA*
[b] *Department of Comparative Medicine, University of Tennessee–Knoxville, 2407 River Drive, Knoxville, TN 37996-4500, USA*
[c] *National Animal Health Monitoring System, USDA: APHIS: US, 555 South Howes, Fort Collins, CO 80521, USA*

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Abstract

Human toxoplasmosis is an infection that has multiple sources: consumption of pork and lamb, water, and handling cat litter and garden soil. While some are, many are not related to livestock production methods. Therefore, there are weak market signals to farmers to change pig production systems, even when there are clear data indicating that pig confinement systems significantly lower the probability of pork being contaminated with the parasite, *Toxoplasma gondii*. We investigated cost differences for pig production systems. While confinement buildings are more expensive, these costs are offset by the greater feed and bedding costs in non-confinement production. There is a "slight cost advantage" of $0.31 per hundred weight for pigs produced in a confinement system.

1. Introduction

Roberts and Frenkel (1990) have estimated that toxoplasmosis can cost US consumers from $0.4 to $8.8 billion per year. In humans, prevalence is commonly 25–50% in the US and Europe (Cook et al., 1990; Roghmann et al., 1999). Fetal infection can cause stillbirths, abortions, early infant mortality, blindness, and mental retardation in children. Transmission of *Toxoplasma gondii* to humans is poorly characterized, but risk factors associated with infection include contact with cats, contact with soil or gardening activities, and consumption of raw or undercooked meat containing infectious bradyzoites (Etheredge & Frenkel, 1995). *T. gondii* is infectious for essentially all warm-blooded animals, including mammals, marsupials, and birds. Species in the family Felidae (cats) are the definitive hosts of *T. gondii*.

Like humans, swine become infected by ingesting oocysts from the environment or by consuming raw or undercooked meats that contain bradyzoites, such as *Toxoplasma*-infected rodent carcasses. Toxoplasmosis is common in domestic swine throughout the world. Recent reports provide prevalence estimates that range from 3.1% to 20.8% in the US (Kliebenstein et al., 1997; Patton et al., 1996). The frequency of infection in swine is distinctly age dependent, with prevalence in market animals in the US approximately half (3.1–9.0%) that of sows (9.4–20.8%).

Toxoplasmosis in swine is a food safety issue, as opposed to an animal health issue. There is, however, uncertainty about the precise risk *T. gondii* poses to the US meat consumer. Risk varies from country to country depending on food consumption and preparation habits. Regardless, from the consumers' perspective, toxoplasma-free pork is a more desirable food product. For producers' a commodity perceived as safer and more wholesome gains a competitive advantage in the marketplace. Both of these goals are compatible with the benefits gained by society through reduced *T. gondii* infections in humans and animals. Therefore, the purpose of this study was to identify pig production facility and farm management practices associated with reduced toxoplasmosis in swine with the purpose of formulating recommendations for the prevention of the infection in swine. Pig production costs in alternative systems will also be provided.

* Corresponding author. Tel.: +1-515-294-7111; fax: +1-515-294-4545.
E-mail address: jklieben@iastate.edu (J. Kliebenstein).

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2. Materials and methods

Data for this study were obtained from a random survey of US swine herds conducted by the National Animal Health Monitoring System (NAHMS) during 1995 (Losinger et al., 1998). As part of the study, general farm management information and blood sera were collected from sows and market hogs on 285 swine farms in 16 states. These data included specific information on production facilities, biosecurity measures, management practices, pig inventory, etc. Among the 285 herds participating in blood sera collection, serum samples were collected from sows in 226 herds and from market hogs in 282 herds. Serum samples from up to 30 randomly selected animals were collected from each herd; 15 from sows and 15 from market livestock. Due to the potential for sampling error, sow herds were dropped from the analysis if fewer than 10 sows were sampled and all tested negative. If fewer than 15 market hogs were tested and all tested negative, the herd was dropped from the analysis. There were 207 sow herds and 213 market herds utilized in the analysis. Following collection, samples were archived at the United States Department of Agriculture (USDA), National Veterinary Services Laboratories (NVSL) and stored at −40 °C until assayed for serum antibodies against *T. gondii* by the University of Tennessee Parasitology Laboratory. A total of 3236 individual sow serum samples and 4712 individual market hog serum samples were assayed for the study.

Sera were tested for antibodies by the modified direct agglutination test (MAT) which uses formalin-fixed tachyzoites as antigen (Patton & Funk, 1992). Samples with antibody titers of $\geqslant$ 1:32 were considered positive. Studies have shown that the MAT is the most sensitive test for the serodiagnosis of toxoplasmosis (Dubey & Beattie, 1988; Patton, Legendre, McGavin, & Pelletier, 1991). A positive titer indicates that at some time in its life the pig has been infected with *T. gondii*. A herd was considered positive if one or more animals tested positive. It was negative if all animals tested negative.

3. Results

8% of all swine tested for *T. gondii* antibodies were positive. 15% of the sows tested positive, while 3.2% of the market hogs tested positive. The prevalence rate was significantly higher in the sow herd (about five times higher) than in the market hog herd. Of the farms, 51% were positive for *T. gondii* (at least one positive animal); 56% of the sow herds were positive while 19% of the market hog herds were positive. When comparisons were conducted by herd size it showed that negative sow herds were significantly larger (647 sows) than the positive herds (200 sows). Negative finisher herds averaged 3635 market pigs in inventory, while the positive herds averaged 2081 market pigs in inventory.

For the production facility analysis, the swine herds were placed into two groups: those which had total confinement for all production phases and those which had at least one of the production phases in which pigs had access to the outside through open buildings or direct access to the outdoors. The *T. gondii* status of sows and sow herds with all production phases in confinement (farrowing, nursery and finishing) was compared to herds that were not in total confinement in at least one of the phases. 20% of the sows in facilities which were not all in total confinement were positive and were almost twice as likely to be infected than those in confinement: 12% infected (Table 1). This was significant at the 0.01 level. Additionally, 71% of the non-total confinement sow herds were positive compared to 49% of the total confinement sow herds. Similarly, market hogs on farms that did not have all phases of the operation (farrowing, nursery, grower/finisher) in confinement were significantly more likely to be infected than those on farms that used total confinement throughout (Table 1). Of the finishers on farms that did not have all phases of the operation in confinement, 4.4% were positive for *T. gondii* compared to 2.3% on farms that used total confinement throughout.

Sows and market hogs in production facilities which had cat access were significantly more likely to be pos-

Table 1
Comparison of *T. gondii* seropositivity in sows and market hogs by production facility

Facility type	Number	Percent negative	Percent positive	*P*	Number	Percent negative	Percent positive	*P*
		Sow comparison				Market hog comparison		
Total confinement in all phases	1884	88.4	11.6	<0.01	2096	97.7	2.3	<0.01
Not all total confinement	1149	79.8	20.2		1334	95.6	4.4	
		Farm comparison				Farm comparison		
Total confinement in all phases	128	50.8	49.2	<0.01	129	83.7	16.3	<0.01
Not all total confinement	79	29.1	70.9		84	76.2	23.8	

Excludes 12 sow farms with incomplete facility information.

itive for *T. gondii* than sows and market hogs in production facilities which did not allow cat access. About one-fourth (21%) of the sows in systems which had cat access were positive for *T. gondii* (Table 2). This compared to only 6.7% of the sows in facilities which did not allow cat access. The odds ratio test indicated sows in facilities with cat access were about four times more likely to be positive. For market hogs the odds were even greater; nine times. Information in Table 2 shows that 5.5% of the market hogs in facilities with cat access were positive. This compared to 0.7% for those produced in facilities without cat access.

Results were similar when evaluated by method of rodent control. Sows and market hogs produced in systems that relied on traps and/or bait only as the method of rodent control had significantly lower prevalence levels of *T. gondii*. This is likely an issue of the exclusion of cats. For example, 7% of the sows on farms which used traps and/or bait only for rodent control were positive, as compared to 20.1% which had other rodent control methods incorporated. For market hogs, 26.9% of the farms using more than traps and/or bait for rodent control were positive for *T. gondii*, compared to only 10% of those using traps and/or bait only.

4. *T. gondii* and production costs

A recent study has shown that there is little evidence that *T. gondii* is associated with decreased pig productivity in sow operations (Kliebenstein et al., 1997). Thus, there is not a direct economic incentive through reduced pig production to incorporate management strategies such as production facilities that would lessen the incidence of *T. gondii* in pigs. With this information on *T. gondii* impacts on pig production, and the absence of regulation, decisions which will drive adoption of production systems will be based on any differences in pork production cost between the systems. Given this, it is necessary to evaluate production costs between alternative production systems to determine if there are cost advantages. A recent study by Brewer, Kliebenstein, Honeyman, Penner, and ASL-R1686 (2000) compared the cost of producing market hogs in two alternative production systems. It compared a hoop system with a confinement system. The hoop system is a low facility cost system which is open on both ends of the pig containment area. There is cat and bird access. The confinement system is totally enclosed, with no access of cats, birds, etc. Information for the cost comparisons was obtained from a side-by-side system comparison.

The cost of production was based on a facility cost of $180 per pig space for a confinement building and $55 per pig space for the hoop structure. Annual fixed costs were calculated at 13.2% of total investment for confinement and 16.5% for hoops. Confinement facilities were depreciated over 15 years (6.7% annually), whereas hoops were depreciated over 10 years (10% annually). Insurance and taxes represent 1.5% of fixed investment. 10% interest was assumed for both systems. Fuel, repairs, utilities, vet, medical, marketing and miscellaneous were based on Iowa State University livestock enterprise budgets (Lawrence & Vontalge, 2000). The bedding cost for the hoop system was for 195 pounds of cornstalks per pig; with a 1200 lb bale valued at $20 per bale. Labor was valued at $10 per hour with 0.20 h per pig and 0.27 h per pig needed, respectively, for confinement and hoop pigs. Feed efficiency was 2.98 lb of feed per pound of gain for confinement and 3.05 for hoop pigs. With a feed cost of $0.06/lb, the resulting feed costs per pig for confinement and hoops were $40.07 and $41.11, respectively.

Overall, the cost of production was comparable between the two systems. The confinement system showed a slight cost advantage of $0.31 per cwt market weight sold. The main cost differences in the two systems were housing cost, feed, and bedding. Hoop systems require more feed and bedding, while facility costs are higher for confinement systems.

Given similar economic results, operator preference and available resources will guide the production system choice and production decision. Decisions will depend upon such factors as management style, preferences, availability of capital, and availability of bedding. Ad-

Table 2
Comparison of *T. gondii* seropositivity in sows and market hogs by cat access to production facilities

Item	Number	Percent negative	Percent positive	*P*	Number	Percent negative	Percent positive	*P*
		Sow comparison				Market hog comparison		
Cat access	1917	79.0	21.0	<0.01	2469	94.5	5.5	<0.01
No cats	1241	93.3	6.7		1943	99.3	0.7	
		Farm comparison				Farm comparison		
Cat access	132	31.8	68.2	<0.01	148	72.3	27.7	<0.01
No cats	84	59.5	40.5		108	89.8	10.2	

Excludes three farms with incomplete rodent control information.

ditionally, information on parasite loads in the system, as well as potential food safety issues and impacts such as *T. gondii*, should also be considered. However, this can be difficult, as the pork production industry is not currently set up to effectively transfer a number of the food safety impacts to the point of origination. Traceback is limited.

5. Summary and conclusions

This paper illustrates the food safety information problem and how it hinders economic incentives to improve food safety. Human toxoplasmosis is an infection that has multiple sources. Some are associated with livestock production methods, while others are not. Thus there are very weak market signals to farmers to change production systems, even when there are clear data indicating that pig confinement systems significantly lower the probability of pork being contaminated with the parasite, *T. gondii*. Results from this and other studies have shown a clear association between pork production systems which are accessible to *T. gondii* vectors, such as cats, and seropositivity of hogs for *T. gondii*. Sows and market hogs in pork production systems which had total confinement facilities in all phases, no cat access, were significantly less likely to be seropositive for *T. gondii*. Of the market hogs tested, 4.4% facilities with cat access were positive, as compared to 2.3% of the hogs from all confinement facilities. Moreover, pigs produced in systems that used bait and/or traps as the only method of rodent control had significantly fewer animals seropositive for *T. gondii*. Additionally, it has been shown that there is little evidence that *T. gondii* is associated with decreased pig productivity. Thus, there is little direct economic incentive for producers to use production strategies which would lead to reduced *T. gondii* levels in pigs. Furthermore, a recent study has shown similar pig production cost between confinement systems and systems such as hoops which are more open and accessible by cats.

While the economic impacts from *T. gondii* on pig production are non-existent, the importance of the issue to the industry should not be overlooked, as the indirect impacts from fetal infection in humans, etc., can be substantial. Roberts and Frenkel (1990) have shown that for the US, estimates of income and other preventable costs caused by toxoplasmosis range from $0.4 to $8.8 billion annually. Reducing the level of toxoplasmosis can have a direct impact on consumers. Given this, and the lack of direct economic incentives for pork producers, industry programs would be helpful in assisting consumer and producer benefits to match better. Moreover, consumer assurance of the safety of pork is vital to continued and enhanced demand for pork, both domestically and internationally. Consumers are becoming increasingly aware of food-borne pathogens and the demand for safe food products is increasing. A *T. gondii* food-safety incident related to pork would erode the consumer image of pork, potentially leading to reduced demand, at least in the short term. The industry needs to evaluate methods of reducing levels of *T. gondii* in pigs and vector, such as cat, accessibility to pig production systems.

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